

## Biology and Systematics of New World *Heterospilus* (Hymenoptera: Braconidae) Attacking Pemphredoninae (Hymenoptera: Sphecidae)

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*Abstract.*—Four new species of the braconid genus *Heterospilus* are described from Brazil and Costa Rica and a key to the five species known to attack crabronid wasps of the genera *Microstigmus* and *Spilomena* is presented. Biological notes are given for the hosts and the parasitoids and comments on their relationships are also offered.

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The genus *Heterospilus* Haliday is one of the largest of the family Braconidae with an estimated 500 or more species in the New World, most of which are undescribed. The genus belongs to the subfamily Doryctinae characterized by a circular opening present between the clypeus and mandibles (oral cavity) and a row of stout spines along the anterior edge of the fore tibia. It can be distinguished from most other braconid genera by the reduction or absence of fore wing vein 2RS and can be identified by the key to genera in Marsh (1997).

We have very little information about the biology of species in the genus *Heterospilus*, which are, as far as known, idiobiont ectoparasitoids (Shaw and Huddleston 1991). Most records suggest parasitism of wood boring Coleoptera, especially Scolytidae, but a few species have been reared from stem boring Lepidoptera and one species from stem boring Symphyta. However, in an unusual host association, one species has been described from nests of the crabronid wasp genus *Microstigmus* Ducke (Richards 1935; Matthews 1968).

Recently, one of us (GARM) reared several species of *Heterospilus* from nests of species of *Microstigmus* and *Spilomena* Shuckard that were being studied in Brazil and Costa Rica. The purpose of this paper is to provide descriptions of four new species of *Heterospilus* and present a brief discussion of the biologies of the hosts and parasitoids.

### BIOLOGICAL NOTES

The genus *Microstigmus* constitutes a distinctive group of crabronid wasps, in particular because of the social behavior and the elaborate suspended nests found in several of its species (Matthews 1968; Richards 1972; West-Eberhard 1977; Matthews 1991; Melo in press). *Microstigmus* together with *Arpactophilus* Smith, *Spilomena* and *Xysma* Pate form the subtribe Spilomenina of the Pemphredonini (Menke 1989). Melo (1994) presented evidence that *Microstigmus* is closely related to a group of species within *Spilomena* containing *S. alini* Antropov, *S. kimseyi* Antropov and other related undescribed species. The use also of *S. alini* as host by *Heterospilus*,

reported here for the first time, therefore should not be considered unexpected. *Heterospilus* has not been found parasitizing other species of Neotropical *Spilomena* whose nests have been studied (Melo unpubl.).

Very little is known about the biology of *Heterospilus* attacking *Microstigmus* wasps. The only available information is provided by Matthews (1968, 1991), Richards (1972) and Melo and Campos (1993). Matthews (1968, 1991) reported on some aspects of the biology of *H. microstigma* Richards parasitizing *M. comes* Krombein, and Melo and Campos (1993) reported *M. myersi* Turner being parasitized by a then undescribed species of *Heterospilus*, here named *H. matthewesi*, new species.

Parasitoid females have never been found inside the host nests and apparently always lay eggs directly from the outside. The positive correlation between the length of the parasitoid ovipositor and the thickness of the host nest wall found among the different species of *Heterospilus* (see below) provides additional evidence for this behavior. Matthews (1968) observed females of *H. microstigma* crawling over nests of *M. comes* and inserting their ovipositors repeatedly into the nest. He was not able to ascertain if these insertions represented only probing or repeated ovipositions. However, considering that only one egg or small parasitoid larva has been found on each of the attacked host immatures and that in most *Microstigmus* nests no more than one immature in the appropriate stage is likely to be found, these insertions may be only for probing or for stinging and paralysis of the host larva.

Only host pre-pupae seem to be attacked, since eggs and small larvae of *Heterospilus* have been found only on immatures at this stage. The pre-pupal stage in *Microstigmus* is relatively short because these wasps are not known to enter diapause, although data on the duration of this stage is lacking. The egg is laid di-

rectly on the surface of the integument of the host larva. Parasitized larvae seem to have their development interrupted which as probably caused by pre-oviposition stinging. In their Table 1, Melo and Matthews (1997) gave a record of a small parasitic larva, attributed by them to *Heterospilus*, on a male pupa of *Microstigmus flavus* Melo and Matthews (this record was erroneously printed as associated with nest 308 instead of nest 303). Since no adult *Heterospilus* has been reared from nests of this species of *Microstigmus*, it is possible that this larva represents another species of parasitoid (the only record of an unidentified Chalcididae attacking *Microstigmus* was obtained from this species), and not the result of exceptional behavior by a female *Heterospilus*.

The length of the female ovipositor is clearly correlated with the thickness of the host nest wall or the distance of the brood cells from the nest outer surface. The longest ovipositors are found in *H. richardsi*, new species, a species attacking *Spilomena alini* and an undescribed species of *Microstigmus*. In both host species, the brood cells are usually situated deep inside the nests (see account under *H. richardsi*). The second longest ovipositors are found in females of *H. matthewesi*, new species, a species associated with *M. myersi*. The thickness of the nest walls in *M. myersi* is quite variable (Melo and Campos 1993). This variation seems to be related to the nest age, with young nests having thinner walls and older nests tending to have an extra covering layer of dirt particles. The females of the other *Heterospilus* species have shorter ovipositors and attack *Microstigmus* species whose nest walls are relatively thin.

Matthews (1991) found a strong correlation between the number of brood cells in nests of *M. comes* and frequency of parasitism by *H. microstigma*; almost all parasitized nests had eight or more cells. He explained this pattern also in terms of the relation between the length of the parasit-

oid ovipositor and the thickness of the host nest walls. Cells in nests with few cells tend to be centrally placed and to have thick walls, and therefore are out of reach for the short ovipositor of females of *H. microstigma*. New cells are sequentially added toward the periphery of the nest and as their number increases, the outer wall of the nest becomes thinner, making the cells more accessible to the parasitoid's ovipositor. Except for silk secreted by females, addition of new construction material to the nest as it grows, a behavior observed for example in *M. meyersi* (Melo and Campos 1993), does not occur in *M. comes* (Matthews and Starr 1984), the new cells being added by stretching the nest walls and holding the newly created pockets (future cells) with silk.

One would expect females of *Heterospilus* to have an ovipositor long enough to cope with this kind of variation in wall thickness of the host's nests, since a long ovipositor could reach deep cells as well as those closer to the nest surface. However, considering the situation found in *H. microstigma* this does not seem to be the case. Apparently these parasitic wasps are under strong selective pressure to have the length of their ovipositor matching very closely the average depth of the majority of their host's cells. As more material becomes available, it would be interesting to investigate the amount of intraspecific variation in ovipositor length.

Cocoon spinning by larvae of *Heterospilus* also varies among the species described here. Matthews (1968) mentioned that *H. microstigma* spins an opaque white cocoon, usually near the bottom of the host cell. Melo and Campos (1993) observed that larvae of *H. matthewsi* spin very rigid cocoons, which adults of *M. meyersi* are apparently unable to open. Cells of *M. meyersi* successfully parasitized by *H. matthewsi* become useless after emergence of the adult parasitoid. The larvae of *H. richardsi* spin cocoons somewhat thicker than those of *H. microstigma*, but

much thinner than in *H. matthewsi*. On the other hand, mature larvae and pupae of *H. brasilophagous*, new species, and *H. arleiophagous*, new species, were not encased by any sort of conspicuous cocoons. This apparent absence of cocoon spinning behavior needs confirmation, however, because cells of *Microstigma* are lined with silk and it would have been easy to overlook a very loose cocoon adhered to the cell walls. Newly emerged adults of *Heterospilus* leave their host's nests directly to the outside by chewing a hole in the nest wall, without passing through the nest entrance. In active nests, these emergence holes are sealed later on with silk and particles by the *Microstigma* females.

Body color also varies in an interesting way among the present species of *Heterospilus*. Species of *Heterospilus* attacking *Microstigma* with a predominately black integument (including *S. alimi*) also have a dark body color, whereas species associated with light colored *Microstigma* (predominately or entirely yellow) have a light body color. The significance of this variation in body color is unknown.

The species of *Heterospilus* show a high degree of specificity regarding their hosts. Four of the present species are associated with only one species of *Microstigma* (*H. matthewsi*, *H. arleiophagus*, *H. brasilophagus*) or at most with a group of closely related species (*H. microstigma*). Only *H. richardsi* is known to attack hosts in different groups, but even in this case the two hosts nest in the same type of habitat. Most of the material used in the present study was collected by the second author while studying the biology of *Microstigma* and *Spilomena* wasps in the region of Viçosa (Minas Gerais, southeastern Brazil). Except for *H. microstigma*, the remaining four species coexist sympatrically in this locality. The hosts of *H. microstigma*, *Microstigma* species in the group *theridii*, are known only from the Amazon basin and Central America. Judging from this degree of specificity, additional collecting will

probably reveal twice as many species of *Heterospilus* attacking these crabronid wasps.

Additional biological notes are included with the descriptions of the *Heterospilus* species presented below.

#### TAXONOMY OF *HETEROSPILUS*

Although the genus *Heterospilus* is large and badly in need of study for the entire Western Hemisphere, preliminary study indicates there will be many distinct spe-

cies groups. The species in this study fall in a group with the following characters: vertex, mesonotum and mesopleuron coriaceous (Figs. 9–11); flagellum unicolorous without white band or tip; metasomal tergum 2+3 with two transverse scrobiculate grooves which enclose a slightly raised median area (Figs. 6–8, see arrow on Fig. 6). The following key is based heavily on characters found in the female although it will work with most males also. The identification of males is best done by associated rearings.

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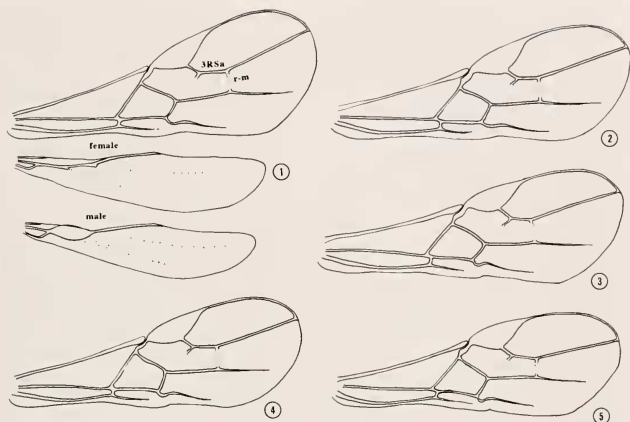
#### KEY TO *HETEROSPILUS* SPECIES PARASITIC ON *MICROSTIGMUS* AND *SPILOMENA*

- |       |  |   |
|-------|--|---|
| 1.    | Body of both sexes entirely brown .....  | 2 |
| -     | Body of both sexes honey yellow, metanotum and metasomal terga occasionally marked with brown .....  | 3 |
| 2(1). | Ovipositor of female equal to or longer than metasoma; fore wing with vein 3RSa longer than r-m (Fig. 1); hind femur yellow or at most yellowish-brown .....   |   |
|       | ..... <i>richardsi</i> Marsh and Melo, new species   |   |
| -     | Ovipositor $\frac{1}{2}$ to $\frac{3}{4}$ length of metasoma; vein 3RSa equal to r-m (Fig. 2); hind femur brown on apical $\frac{3}{4}$ , yellow on basal $\frac{1}{4}$ .....                                  |   |
|       | ..... <i>matthewsi</i> Marsh and Melo, new species   |   |
| 3(1). | Antennal flagellum yellow, first flagellomere longer than second; forewing vein 3RSa longer than r-m (Fig. 5); ovipositor of female usually equal to length of second and third metasomal terga combined ..... |   |
|       | ..... <i>microstigma</i> Richards  |   |
| -     | Antennal flagellum black, first flagellomere usually equal to second; forewing vein 3RSa equal to or shorter than r-m; ovipositor usually equal to length of first metasomal tergum .....                      | 4 |
| 4(3). | Fore wing vein 3RSa equal to vein r-m (Fig. 4); median transverse area of metasomal terga 2+3 (between transverse scrobiculate grooves) coriaceous medially, striate laterally .....                           |   |
|       | ..... <i>brasilophagus</i> Marsh and Melo, new species   |   |
| -     | Fore wing vein 3RSa shorter than vein r-m (Fig. 3); median transverse area of metasomal terga 2+3 entirely coriaceous .....  |   |
|       | ..... <i>arleiophagus</i> Marsh and Melo, new species  |   |
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#### *Heterospilus arleiophagus* Marsh and Melo, new species (Fig. 3)

*Female*.—**Body color:** head yellow, palpi light yellow, antennal flagellum black, first flagellomere yellow at base, pedicel black, scape yellow with black longitudinal stripe on outer edge; mesosoma yellow, metanotum, sides of scutellum and propodeum occasionally black; legs yellow, wings slightly dusky, veins brown; metasoma yellow, first tergum occasionally marked with brown laterally, terga 2–

4 marked with brown medially. **Body length:** 2.5 mm. **Head:** vertex and frons weakly coriaceous, face and temple smooth; 26–27 antennomeres, first flagellomere equal in length to second; malar space about  $\frac{1}{2}$  eye height. **Mesosoma:** pronotum coriaceous dorsally with median scrobiculate groove; mesonotal lobes coriaceous, median lobe with median longitudinal depression, notauli scrobiculate and meeting in a wide rugulose area nearly as wide as scutellum; scutellum coriaceous; mesopleuron coriaceous, sternaulus short and weakly scrobiculate; propo-



Figs. 1-5. Wings of *Heterospilus* species: 1, *richardsi*, new species; 2, *matthewsi*, new species; 3, *arleiphagus*, new species; 4, *brasillophagus*, new species; 5, *microstigma* Richards.

deum rugose with small basal lateral coriaceous spots. **Legs:** fore tibia with row of 4-6 short spines. **Wings:** fore wing vein 3RSa shorter than vein r-m (Fig. 3). **Metasoma:** first tergum slightly longer than apical width, carinate rugulose, raised median area not set off by carinae; second tergum carinate, transverse median area between two transverse scrobiculate grooves entirely coriaceous; third tergum coriaceous; remainder of terga weakly coriaceous; ovipositor as long as first metasomal tergum.

**Male.**—Agrees with description of female except as follows: scape usually entirely yellow; hind wing with oblong stigma at base (as in Fig. 1).

**Holotype.**—Female: BRAZIL, Viçosa, MG, January 28, 1990, G. A. R. Melo, collected in nest of *Microstigma arlei*, nest 330. Deposited in the Museu de Zoologia, Universidade de São Paulo, Brazil.

**Paratypes.**—BRAZIL: 2 females, 1 male,

same data as holotype with additional dates of August 7, 1990 and February 2, 1992, nests 330, 367, 368, 603. Deposited in the Museu de Zoologia, Universidade de São Paulo, Brazil.

**Biology.**—Reared from nests of *Microstigma arlei* Richards. This *Microstigma* species makes suspended petiolated nests. The nests have been found attached only to surfaces other than plant leaves, like inclined tree trunks or branches, earth bank walls, and structural timber of exposed roofs of huts; the nests reported by Richards (1972) were hanging from the face of a rock. Cocoons have not been observed for this species.

**Etymology.**—The species name is based on the host wasp.

***Heterospilus brasillophagus* Marsh and Melo, new species**  
(Fig. 4)

**Female.**—**Body color:** head yellow, palpi light yellow, antennal flagellum black,

first flagellomere yellow at base, pedicel black, scape yellow with black longitudinal stripe on outer edge; mesosoma yellow, metanotum, sides of scutellum and scutellar sulcus black; legs yellow; wings slightly dusky, veins brown; metasoma yellow, terga 2–3 marked with brown. **Body length:** 2.5 mm. **Head:** vertex and frons weakly coriaceous, face and temple smooth; 26–27 antennomeres, first flagellomere equal in length to second; malar space about  $\frac{1}{2}$  eye height. **Mesosoma:** pronotum coriaceous dorsally with median scrobiculate groove; mesonotal lobes coriaceous, median lobe with median longitudinal depression, notauli scrobiculate and meeting in a wide longitudinal carinate area nearly as wide as scutellum; scutellum coriaceous; mesopleuron coriaceous, sternaulus short and weakly scrobiculate; propodeum rugose with small basal lateral coriaceous spots. **Legs:** fore tibia with row of 4–6 short spines. **Wings:** fore wing vein 3RSa usually as long as r-m (Fig. 4). **Metasoma:** first tergum slightly longer than apical width, carinate rugulose, raised median area not set off by carinae; second tergum carinate, transverse median area between two transverse scrobiculate grooves coriaceous, striate laterally; third tergum coriaceous; remainder of terga weakly coriaceous; ovipositor as long as first metasomal tergum.

**Male.**—Essentially as in female; hind wing with oblong stigma at base; with 25–27 antennomeres.

**Holotype.**—Female: BRAZIL, Viçosa, MG, February 15, 1992, G.A.R. Melo, collected in nest of *Microstigmus brasiliensis*, nest 582. Deposited in the Museu de Zoologia, Universidade de São Paulo, Brazil.

**Paratypes.**—BRAZIL: 5 males, same data as holotype with additional date of July 25, 1992, nests 579, 580, 619. Deposited in the Museu de Zoologia, Universidade de São Paulo, Brazil.

**Biology.**—Reared from nests of *Microstigmus brasiliensis* Melo. This *Microstigmus* species builds the type of pendulous nests

considered typical for this genus (see Richards 1972, West-Eberhard 1977); its nests were described and illustrated in Melo (1992).

**Etymology.**—The species name is based on the host wasp.

***Heterospilus matthewsi* Marsh and  
Melo, new species  
(Figs. 2, 6)**

**Female.**—**Body color:** head brown, palpi yellow; scape yellow with brown longitudinal strip laterally, pedicel brown, flagellum dark brown; mesosoma and metasoma dark brown; legs yellow, hind femur brown on apical  $\frac{3}{4}$ ; wings hyaline, veins light brown, tegula yellow. **Body length:** 3 mm. **Head:** vertex and frons finely coriaceous, temple smooth, face smooth with fine striations laterally; 26–28 antennomeres; malar space about  $\frac{1}{3}$  eye height; maxillary palpus longer than fore tarsus. **Mesosoma:** pronotum coriaceous and shining dorsally with median scrobiculate groove; mesonotal lobes finely coriaceous, median lobe with median longitudinal depression, scutellum finely coriaceous and shining; mesopleuron coriaceous, sternaulus short and weakly scrobiculate; propodeum rugose, median rugae more distinct indicating vague areola, small basal lateral coriaceous spots. **Legs:** fore tibia with row of 4–5 short spines on anterior edge. **Wings:** fore wing with vein 3RSa equal in length to or slightly longer than vein r-m (Fig. 2). **Metasoma** (Fig. 6): first tergum slightly longer than apical width, carinate rugulose, median raised area set off by complete distinct longitudinal carinae; second tergum weakly carinate coriaceous, ending in distinct transverse scrobiculate groove; third tergum with second transverse scrobiculate groove which meets first groove at sides, tergum carinate coriaceous before this groove and beyond to end of tergum; remainder of terga finely coriaceous and shining; ovipositor  $\frac{1}{3}$  to  $\frac{1}{2}$  length of metasoma.

*Male*.—Essentially as in female; hind wing with oblong stigma at base.

*Holotype*.—Female: BRAZIL, Viçosa, MG, February 10, 1992, G. A. R. Melo, collected in nest of *Microstigmus myersi*, nest 586. Deposited in the Museu de Zoologia, Universidade de São Paulo, Brazil.

*Paratypes*.—BRAZIL: 3 females, 2 males, same data as holotype with additional dates of March 16, 1992, July 31, 1992, January 28, 1990, nests 585, 586, 610, 620, 637; 1 female, Vargem Alta, ES, September 4, 1992, J. N. C. Louzada, collected in nest of *Microstigmus myersi*, nest 637; 1 male, Belo Horizonte, MG, July 18, 1992, J. N. C. Louzada, collected in nest of *Microstigmus myersi*. Deposited in the Museu de Zoologia, Universidade de São Paulo, Brazil.

*Biology*.—Reared from the nests of *Microstigmus myersi* Turner. Some aspects of the biology of *H. matthewsi* were presented in Melo and Campos (1993); this species was referred to as *Heterospilus* sp. in their paper. The rigid cocoons spun by its larvae set *H. matthewsi* apart from other *Heterospilus* attacking *Microstigmus*, whose larvae spin only a thin cocoon or no cocoon at all. It would be interesting to investigate the significance of these rigid cocoons.

*Distribution*.—Known only from Brazil.

*Etymology*.—Named for R. W. Matthews who gave the first complete description of the biology of *Heterospilus microstigma* (see Matthews 1968).

***Heterospilus microstigma* Richards**  
(Figs. 5, 7, 9–11)

*Heterospilus microstigma* Richards 1935:131. Holotype female, deposited in The Natural History Museum, London.

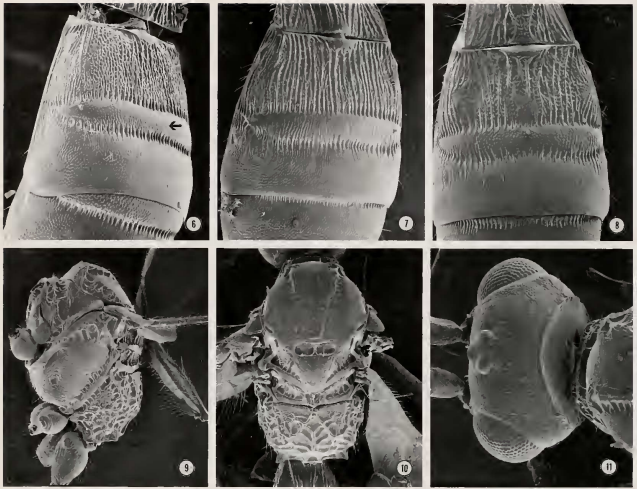
*Female*.—**Body color**: head, mesosoma and metasoma yellow or honey-yellow, mesonotal lobes, metanotum, propodeum dorsally, and metasomal terga 1–4 often marked with brown; antenna varying from entirely brown to scape, pedicel and basal flagellomeres yellow, apical flagel-

lomes brown; legs yellow; wings hyaline or slightly dusky, veins light brown, tegula yellow. **Body length**: 2.5–3.0 mm. **Head**: vertex and frons finely coriaceous (Fig. 11), face and temple smooth; 24–28 antennomeres; malar space about  $\frac{1}{2}$  eye height; maxillary palpus longer than fore tarsus. **Mesosoma** (Figs. 9, 10): pronotum coriaceous and shining dorsally with median scrobiculate groove; mesonotal lobes finely coriaceous, median lobe with median longitudinal depression, scutellum finely coriaceous; mesopleuron coriaceous, sternaulus short and weakly scrobiculate; propodeum rugose, median rugae more distinct indicating vague areola, small basal lateral coriaceous spots. **Legs**: fore tibia with row of 4–5 short spines on anterior edge. **Wings**: fore wing with vein 3RSa about equal in length to vein r-m (Fig. 5). **Metasoma** (Fig. 7): first tergum slightly longer than apical width, carinate rugulose, median raised area set off by short indistinct basal carinae; second tergum carinate rugulose, ending in distinct transverse scrobiculate groove; third tergum with second transverse scrobiculate groove which meets first groove at sides, tergum carinate rugulose before this groove, strongly coriaceous beyond to end of tergum; remainder of terga coriaceous; ovipositor  $\frac{1}{2}$  to  $\frac{3}{4}$  length of metasoma.

*Male*.—Essentially as in female; hind wing with oblong stigma at base.

*Distribution*.—Trinidad, Costa Rica, Brazil. For this study we have seen 23 specimens from the following localities in Brazil: Manaus, AM; Beruri, AM; Viçosa, MG; Mato Grosso.

*Biology*.—Previously reared from nests of *Microstigmus theridii* Ducke and *M. comes* Krombein (Richards 1935; Matthews 1968, 1991). Specimens from this study have been reared from nests of species of the *M. theridii* group which includes *M. comes* (nests 442, 443, 447, 531). This species group is restricted to northern South America and Central America (Melo unpubl.)



Figs. 6-11. Body parts of *Heterospilus* species: 6, metasoma, *matthewsi*, new species (arrow points to raised median area mentioned in the descriptions); 7, metasoma, *microstigma* Richards; 8, metasoma, *richardsi*, new species; 9, mesosoma, lateral view, *microstigma*; 10, mesosoma, dorsal view, *microstigma*; 11, vertex, *microstigma*.

*Heterospilus richardsi* Marsh and Melo,  
new species  
(Figs. 1, 8)

**Female.**—**Body color:** head brown, face light brown, palpi yellow; scape yellow with brown longitudinal strip laterally, pedicel brown, flagellum dark brown; mesosoma and metasoma dark brown; legs yellow; wings hyaline, veins light brown, tegula yellow. **Body length:** 3 mm. **Head:** vertex and frons finely coriaceous, temple smooth, face smooth with fine striations laterally; 24-26 antennomeres; malar space about  $\frac{1}{3}$  eye height; maxillary palpus longer than fore tarsus. **Mesosoma:** pronotum coriaceous and shining dorsally with median scrobiculate groove; mesonotal lobes finely coriaceous, median lobe with median longitudinal depression, scu-

tellum smooth and shining; mesopleuron coriaceous, sternaulus short and weakly scrobiculate; propodeum rugose, median rugae more distinct indicating vague areola, small basal lateral coriaceous spots. **Legs:** fore tibia with row of 4-5 short spines on anterior edge. **Wings:** fore wing with vein 3RSa longer than vein r-m (Fig. 1). **Metasoma** (Fig. 8): first tergum slightly longer than apical width, carinate rugulose, median raised area set off by short indistinct basal carinae; second tergum carinate rugulose, ending in distinct transverse scrobiculate groove; third tergum with second transverse scrobiculate groove which meets first groove at sides, tergum carinate rugulose before this groove, smooth beyond to end of tergum; remainder of terga smooth and shining;



ovipositor as long as or longer than metasoma.

*Male*.—Essentially as in female except as follows; scape usually entirely yellow; hind wing with oblong stigma at base.

*Holotype*.—Female: BRAZIL, Araponga, MG, March 22, 1992, G. A. R. Melo, collected in *Spilomena alini* nest. Deposited in the Museu de Zoologia, Universidade de São Paulo, Brazil.

*Paratypes*.—BRAZIL: 1 female, 1 male, same data as holotype; 1 male, Viçosa, MG, April 26, 1989, collected in nest of *Spilomena alini*. COSTA RICA: 3 females, 2 males, Heredia, Estacion Biol. La Selva, 10°25'N, 84°0'W, 80m, June 14, 1996, reared from nests of *Microstigmus* sp., nests 677, 680, GAR Melo. Deposited in the Museu de Zoologia, Universidade de São Paulo, Brazil and the national Museum of Natural History, Washington, DC.

*Biology*.—Reared from the nests of *Spilomena alini* Antropov in Brazil and an undescribed species of *Microstigmus* from Costa Rica closely related to *M. xanthosceles* Melo and Matthews. *Spilomena alini* excavates its nests in earth bank walls and in small soil clumps hanging from rootlets in banks (Carvalho and Zucchi 1989; Melo unpubl.; see Fig. 1 in Melo and Campos (1993) for an illustration of this kind of habitat). Some nests have also been found inside abandoned mud cells of eumenine wasps hanging from roots in banks (in this case, the nest tunnels and cells were dug in the loose detritus filling up the mud cells). *Heterospilus richardsi* was reared only from nests of *S. alini* built in soil clumps. In these nests, some of the host cells are close to the surface, especially in the smaller clumps, and therefore within reach of the parasitoid ovipositor. Nests built within bank walls are apparently protected from parasitism by *Heterospilus*.

The nests of the second host of *H. richardsi*, *Microstigmus* sp., are small to medium bags (3–12 mm long) built on hanging rootlets in earth banks or in tree trunks. The external walls of the nest are

made of soil particles (for nests in banks) or particles of dead wood (nests in tree trunks) aggregated with silk from the female's silk glands. The central part of the nest has a sponge-like appearance and is formed by anastomosing pillars and channels; except in the upper part of the nest, this central portion is not in contact with the external walls. The brood cells are located in the central portion. It seems that only small nests, in which the cells are relatively close to the nest surface, are subject to parasitism by *Heterospilus*. One female and one male of *H. richardsi* were reared from a nest with six *Microstigmus* females (nest 677), while two females and one male were reared from a nest with only one *Microstigmus* female (nest 680). Four additional nests, containing four, five, 11 and 27 adult *Microstigmus* respectively, produced no *Heterospilus*.

*Distribution*.—Brazil, Costa Rica.

*Etymology*.—Named for O. W. Richards who described the first species of *Heterospilus* reared from *Microstigmus* wasps.

### *Heterospilus* species

We have seen one female (nest 598) reared from the nests of an apparently undescribed species of *Microstigmus* species from the *bicolor* group in Viçosa. As in several other species of the group (West-Eberhard 1977), this *Microstigmus* species feeds its larvae progressively with Cicadellidae nymphs. This single female *Heterospilus* is similar to *microstigma* but differs in having the body somewhat more coarsely coriaceous or punctate and darker wings. More specimens are needed to determine if it is a variation of *microstigma* or another species.

Also, we have seen one badly damaged female specimen and one male specimen (nest 403) reared from *Microstigmus leuderwaldti* species group in Manaus, northern Brazil. These specimens are similar to *microstigma* but are darker than identified members of that species. Exact placement

of these must wait until more undamaged specimens are collected.

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